

II. REMARKS

Claims 1-8 have been amended. Specifically, independent claims 1 and 4 have been amended to improve form and grammar, which has no further limiting effect on the scope of these claims. Claims 1 and 4 have also been amended to recite “an object having a surface shape...wherein the boundary representation data inputted comprises three dimensionally shaped data” as supported on page 1, lines 10-12, and on page 11, lines 2-5, of Applicants’ specification as originally filed. Claims 1 and 4 have also been amended to recite “converting the boundary representation data so that the boundary representation data is solidified or merged of a boundary line of a plane and converting surface shape into a triangle patch having a phase” as supported on page 27, lines 2-4, of Applicants’ specification as originally filed. Claims 1 and 4 have also been amended to recite

“integrating ridge lines...without changing the phase, and judging whether or not the following conditions are satisfied...there is not any triangle vertex in a cell body or on a cell surface;...there is only one vertex of the triangle patch on the cell edge; and...a phenomenon does not occur in which the phase changes by integrating the cutting points”

as supported on page 28, lines 8-20, of Applicants’ specification as originally filed.

Independent claim 4 has been further amended so that its preamble recites “a storage unit of a computer encoded with a program for generating volume data, wherein the program causes the computer to execute the steps of” as supported on page 26, lines 22-24, of Applicants’ specification as originally filed. The preambles of dependent claims 5, 6 and 8 have also been amended in accordance with the amendment to the preamble of independent claim 4.

Dependent claims 2, 3 and 5-8 have been amended to improve grammar, and not for a reason related to patentability. Therefore, the present amendment has no further limiting effect on the scope of claims 2, 3 and 5-8.

A. The Invention

The present invention pertains broadly to a method, and a storage unit of a computer encoded with a program that causes the computer to execute the method, of generating volume data from boundary representation data, such as may be applied to volume CAD applications. In accordance with a method embodiment of the present invention, a method of generating volume data from boundary representation data is provided that includes the steps recited by independent claim 1. In accordance with an apparatus embodiment of the present invention, a storage unit of a computer encoded with a program for generating volume data, wherein the program causes the computer to execute the steps recited by independent claim 4, is provided. Various other embodiments, in accordance with the present invention, are recited by the dependent claims.

An advantage provided by the embodiments, in accordance with the present invention, is that a method of generating volume data from boundary representation data is provided that employs a triangle patch of input shape so shape data can be simplified for use in volume CAD applications.

B. The Rejections

Claims 5 and 8 stand rejected under 35 U.S.C. § 112, second paragraph, as indefinite.

Claims 4-6 and 8 stand rejected under 35 U.S.C. § 101 for failing to recite statutory subject matter.

Claims 1-8 stand rejected under 35 U.S.C. § 102(b) as anticipated by Lorensen et al. (William E. Lorensen et al., *Marching Cubes: A High Resolution 3D Surface Construction Algorithm*, 21 COMPUTER GRAPHICS 163-169 (1987), hereafter the “Lorensen Article”).

Applicants respectfully traverse the Examiner’s rejections and request reconsideration of the above-captioned application for the following reasons.

C. Applicants' Arguments

In view of the present amendment, claims 1-8 are now in compliance with 35 U.S.C. § 112.

In view of the present amendment, claims 4-6 and 8 now pertain to a “a storage unit of a computer encoded with a program for generating volume data, wherein the program causes the computer to execute” steps. Applicants contend that claims 4-6 and 8 now recite subject matter that falls within the statutory classes of patentable subject matter established by 35 U.S.C. § 101.

i. The Section 102(b) Rejection

Anticipation under 35 U.S.C. § 102 requires showing the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim. Lindemann Maschinenfabrik GMBH v. American Hoist & Derrick, 221 U.S.P.Q. 481, 485 (Fed. Cir. 1984). In this case, the Examiner has failed to establish a prima facie case of anticipation against claims 1-8 of the above-captioned application because the Lorensen Article does not teach, or suggest, each and every element of the claimed invention.

ii. The Lorensen Article

The Lorensen Article discloses a “marching cubes” algorithm, which is a high resolution 3-D surface construction algorithm that creates triangle models of constant density surfaces from 3-D medical data (See Abstract of the Lorensen Article). The Lorensen Article discloses, in Figure 1, the basic information flow for the algorithm, which includes (1) data acquisition using a CT scanner, MRI or SPECT apparatus, (2) image processing that employs image processing techniques to find structures within 3D data, or to filter the data, (3) surface

construction that involve the creation of a surface model from 3D data, wherein the model consists of 3D volume elements and users select the desired surface by specifying a density value, and (4) displaying the surface created by the previous steps (Lorensen Article, at 163, col. 2, line 23, to 164, col. 1, line 37). The Lorensen Article discloses an algorithm of surface construction that employs a “divide-and-conquer” approach that uses triangulated cubes as shown in Figure 3 (Lorensen Article, at 164, col. 2, line 26, to 166, col. 1, line 16).

However, the Lorensen Article does not teach, or suggest, “inputting boundary representation data of an object...into a computer...wherein the boundary representation data inputted comprises three dimensionally shaped data” as recited by independent claims 1 and 4 of the above-captioned application. Instead, the Lorensen Article discloses 2D data slices, such as are obtained by a CT scanner or MRI (See Lorensen Article, Figure 1, “Data Acquisition,” and at 163, col. 2, lines 28-32), wherein 3D data is extrapolated from the 2D slice data using an “image processing technique” (See Lorensen Article, at 164, col. 1, lines 22-26). On the other hand, the present invention may utilize, for example, S-CAD data, which is inputted as 3D data (See Applicants’ original specification, at 19, lines 25-27, and at 26, lines 21-24). Therefore, the present invention does not create 3D data from 2D data as does the method disclosed by the Lorensen Article.

This is not the only deficiency in the disclosure of the Lorensen Article. The Lorensen Article discloses, in the section titled “4. Marching Cubes Algorithm,” determining “the topology of the surface within a cube, [then] finding the location of the intersection later” (Lorensen Article, at 164, col. 2, lines 44-46; and Figure 3). The presently claimed invention, on the other hand, does not use the Marching Cubes type algorithm shown in Figure 3 of Lorensen; rather, it directly converts surface shape into the triangle patch (See, e.g., Applicants’ original specification, at 26, line 25, to 27, line 4). Therefore, the Lorensen Article also does not teach, or suggest, “converting the boundary representation data so that

the boundary representation data is solidified or merged of a boundary line of a plane and converting surface shape into a triangle patch having a phase” as recited by independent claims 1 and 4.

The Lorensen Article also does not teach, or suggest, “dividing a space into rectangular parallelepiped cells whose boundary planes cross one another at right angles to associate each cell with a triangle to be included in the associated cell” as recited by independent claims 1 and 4. As described on page 27, lines 13-22, of Applicants’ original specification, the method performs a step wherein each cell is associated with a triangle that is included in the associated cell. In other words, the presently claimed invention operates so that the vertexes of each triangle are located in cells, but not on the ridges of cells. The Lorensen Article, on the other hand, simply creates an index for each case based on the state of the vertex as shown in Figure 4. A person of ordinary skill in the art would instantly appreciate that the present invention is very different from the subject matter shown in Figure 4 of the Lorensen Article.

In Figure 3 of the Lorensen Article, it is shown that, in order to determine the existence of the triangle surface from the index of the vertex, Lorensen et al. “create an index for each case, based on the state of the vertex....This index serves as a pointer into an edge table that gives all edge intersections for a given cube configuration” (Lorensen Article, at 165, col. 1, lines 28-32). The Lorensen Article does not teach, or suggest, “dividing the triangle patch...” as recited by independent claims 1 and 4. The present invention, as claimed, divides the triangle located between cells in this step; therefore, all triangles are located inside or on the ridges of cells. Furthermore, in accordance with the presently claimed invention, some triangles are located inside the cell. This feature of the present invention is also very different from the subject matter disclosed by the Lorensen Article.

As also evident from Figure 3 of the Lorensen Article, Lorensen determines the existence of the triangle surface from the index of the vertex (See also Lorensen Article, at 165, col. 1, lines 28-32). The Lorensen Article is completely silent with respect to ridge line integration. Therefore, the Lorensen Article does not teach, suggest, or even contemplate

“integrating ridge lines without changing the phase, and judging whether or not the following conditions are satisfied

- i. there is not any triangle vertex in a cell body or on a cell surface;
- ii. there is only one vertex of the triangle patch on the cell edge; and
- iii. a phenomenon does not occur in which the phase changes by integrating the cutting points”

as recited by independent claims 1 and 4 of the present application.

With respect to steps (E) and (F) of the presently claimed invention, each triangle and vertex are assigned to a cell with reference to index data of the vertex. According to Lorensen, the data structure of “triangulated cubes” is generated as shown in Figure 3 of the Lorensen Article.

The Lorensen Article also does not teach, or suggest, “checking...whether or not triangle groups satisfying predetermined conditions decreased as a result of ridge line integration; and simplifying...a defective portion in a case where the predetermined conditions are not satisfied, and thereafter performing ridge line integration again” as recited by claims 2 and 5. These steps are described on page 33, line 11, to page 37, line 26, of Applicants’ specification as originally filed. Applicants contend the Lorensen Article is completely silent with respect to these kinds of steps. While the Examiner contends that Lorensen’s 3D display of 2D slice data somehow relates to the subject matter of claims 2 and 5 (Office Action, dated September 28, 2007, at 3, line 22, to at 4, line 5), Applicants disagree. Assuming, *arguendo*, that such steps may be inferred from the Lorensen’s disclosure (which is an invalid assumption), these steps are not enabled, and, therefore, cannot serve as valid prior art. See, e.g., In re Donohue, 226 U.S.P.Q. 619, 621 (Fed. Cir. 1985).

The Lorensen Article also does not teach, or suggest, “the volume data and the triangle patch having the phase are prepared, and set operations of nonboundary cells, the nonboundary cell to a boundary cell, and the boundary cell to the boundary cell are performed based on connected triangles” as recited by claims 3 and 6-8. This subject matter, which is described at 38, line 27, to at 42, line 2, of Applicants’ specification as originally filed, is simply not disclosed by the Lorensen Article. While the Examiner contends that section of Lorensen, at 166, titled “5.1 Enhancements to the Basic Algorithm” discloses this subject matter, Applicants disagree. Specifically, this section pertains to coherence enhancement and the application of Boolean operations to permit cutting and capping of solid models. This section of the Lorensen Article is not relevant to the subject matter of the claimed invention.

In sum, the Lorensen Article discloses 2D input data whereas the presently claimed invention employs “three dimensionally shaped data,” which is 3D input data. The Lorensen Article employs marching cubes that include triangulated cubes, but Lorensen does not teach, or suggest, “converting the boundary representation data so that the boundary representation data is solidified or merged of a boundary line of a plane and converting surface shape into a triangle patch having a phase” and “dividing a space into rectangular parallelepiped cells whose boundary planes cross one another at right angles to associate each cell with a triangle to be included in the associated cell” and “integrating ridge lines without changing the phase” and “judging whether or not” three different conditions are satisfied as recited by the independent claims. With respect to claims 2 and 3, these embodiments relate to appropriately approximating the structure having a size smaller than the cell size, which pertains to a different purpose and to different subject matter than that disclosed by the Lorensen Article.

For all of the above reasons, the Examiner has failed to establish a prima facie case of anticipation against claims 1-8 of the above captioned application.

III. CONCLUSION

In view of the present amendment, claims 1-8 are now in compliance with 35 U.S.C. §§ 101 and 112.

The Examiner has failed to establish a prima facie case of anticipation against claims 1-8 because the Lorensen Article fails to disclose each and every element of the claimed invention.

For all of the above reasons, claims 1-8 are in condition for allowance and a prompt notice of allowance is earnestly solicited.

Questions are welcomed by the below-signed attorney for Applicants.

Respectfully submitted,

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